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Conference Abstract

Scaling Spatial Planning Models to Support Conservation and Land Use Decisions under Climate Change

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Abstract

Global models indicate there is not enough land to simultaneously achieve conservation targets (i.e., conserving 30% of land by 2030, or '30x30') and meet future clean energy and agriculture demands (Brock et al. 2024). Therefore, planning efforts are needed at national scales to find optimal solutions. National-scale mapping can also foster better governance and interagency collaboration to ensure plans meet both national and global commitments (Chaplin-Kramer et al. 2021, Frazier et al. 2024). We integrate diverse, multi-scale living data into dynamic forecasting models to inform actionable and sustainable land use plans to prevent biodiversity and ecosystem service loss while meeting future development needs. We use a minimum set optimization approach to identify priority areas for conservation, energy and agriculture in megadiverse Colombia out to 2050, balancing 30x30 conservation targets with energy and food demands of a growing population. We highlight potential conflict areas between competing land uses under climate change and discuss efforts to better support sustainable land use decisions-making on the ground.

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Methods: We extend a global, multi-sectoral optimization framework (Brock et al. 2024) to prioritize country-level conservation (biodiversity, carbon) and development (renewable energy, crops) targets under four planning scenarios: nature-first; development-first; concurrent; and concurrent 30x30. The nature and development-first scenarios prioritize meeting one sector's targets before considering the other; the two concurrent scenarios evaluate all sector targets simultaneously, with the concurrent 30x30 ensuring at least 30% of land is conserved. Each scenario is modeled with a 'Business as Usual' climate (RCP 6.0) for future targets out to 2050. Scenario outputs are compared to identify areas of potential conflict between conservation and development and compared to a global analysis (Brock et al. 2024). Additional details are in Suppl. material 1.

Results: A comparison of the national- and global-scale models shows considerable disagreement for conservation, less for development Fig. 1, establishing the potential shortcomings of global models to meet national conservation needs and support local land use decisions under climate change.

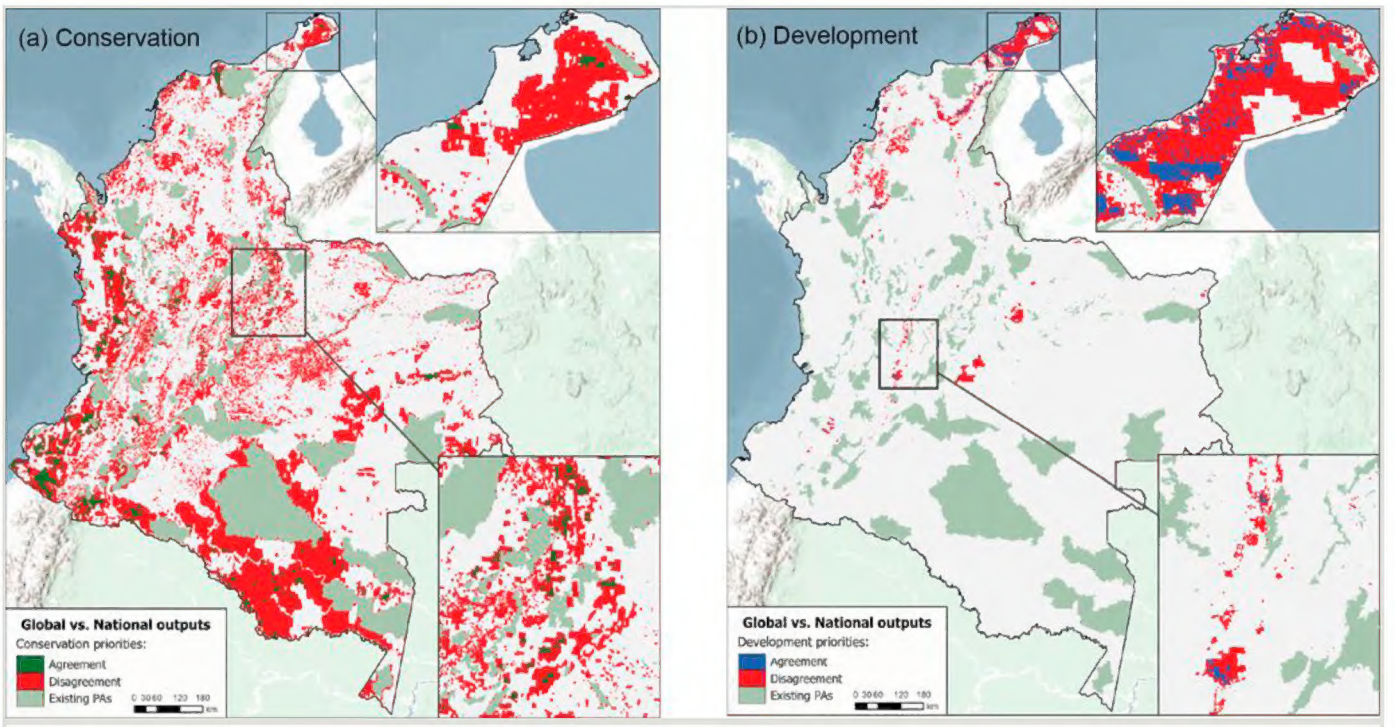

Figure 1.

Comparison of global and national spatial planning outputs in Colombia under future climate change for (a) conservation and (b) development. Areas of model egreement in green (a) and blue (b); areas of model disagreement are in red. Figure credit: Nickolas McManus, Conservation International. CC-BY 4.0

At the national scale, under all scenarios, energy and agriculture require about 40x less land than conservation to meet future targets Suppl. material 1. The majority of land prioritized for conservation in both the nature- and development-first scenarios is in the Amazonia and Pacifica regions, with smaller fragments in the Andes Fig. 2. For energy, the northern Caribbean region La Guajira is a hotspot for meeting wind and solar targets in both scenarios and a hotspot for conflicts with conservation Suppl. material 1.

National scale models built with country-specific projections can minimize potential land conflicts and better support on-the-ground decisions, but data can be difficult to acquire

for model parameterization. The models benefitted from species ranges from BioModelos (Velásquez-Tibatá et al. 2019) to quantify biodiversity, but not all areas have expert-driven data. More broadly, discussions are needed on how best to set targets for biodiversity and carbon. While development targets are generally informed by future population projections and human needs, the science around conservation targets is less established. Additionally, there is a need to incorporate other social and economic factors, such as land tenure, to accurately model potential and explore co-siting of multiple land uses together.

Keywords

systematic conservation planning, prioritizR, climate change, biodiversity, carbon, energy, agriculture, BioModelos, Colombia

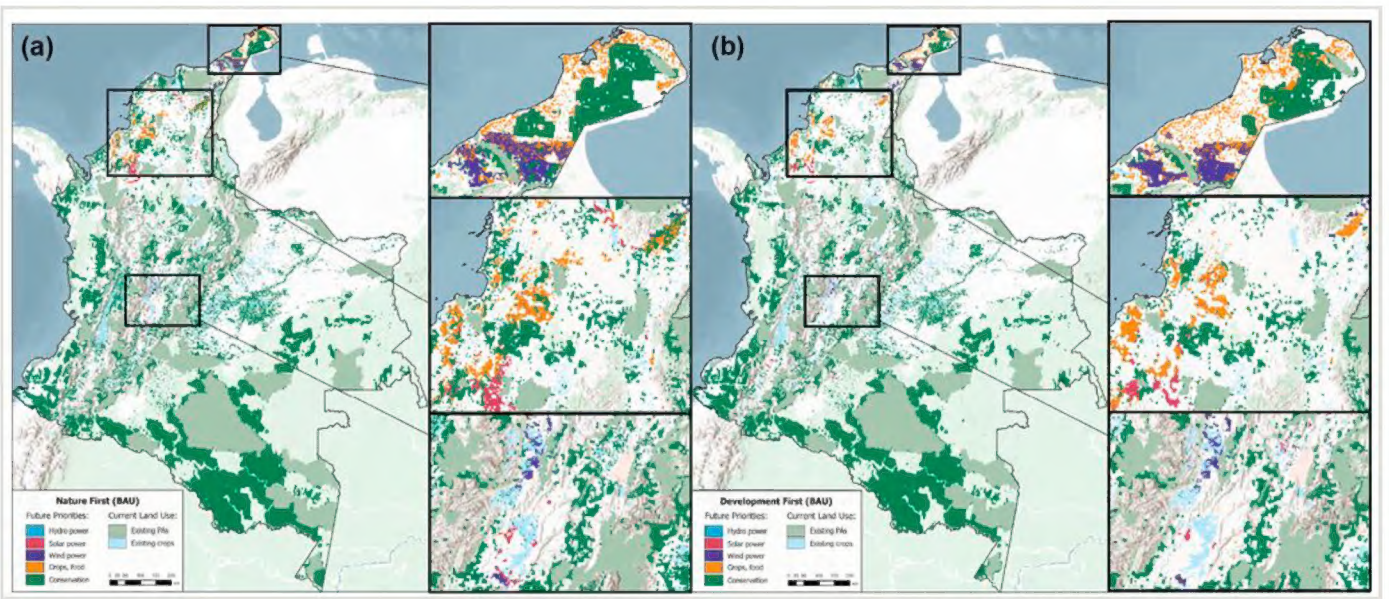

Figure 2.

Future land use allocation in Colombia under an (a) Nature First , and (b) Development First scenarios considering climate change. Figure credit: Nickolas McManus, Conservation International. CC-BY 4.0

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Conflicts of interest

The authors have declared that no competing interests exist.

References

- Brock C, Roehrdanz P, Beringer T, Chaplin-Kramer R, Enquist B, Frazier A, Johnson J, Kennedy C, Kiesecker J, Larsen A, Loyola R, Marquet P, Neugarten R, Oakleaf J, Roopsind A, Schuster R, Williams D, Wu G, Zvoleff A, Hannah L, et al. (2024) Balancing land use for conservation, agriculture, and renewable energy. Research Square https://doi.org/10.21203/rs.3.rs-3798412/v1
- Chaplin-Kramer R, Brauman K, Cavender-Bares J, Díaz S, Duarte GT, Enquist B, Garibaldi L, Geldmann J, Halpern B, Hertel T, Khoury C, Krieger JM, Lavorel S, Mueller T, Neugarten R, Pinto-Ledezma J, Polasky S, Purvis A, Reyes-García V, Roehrdanz P, Shannon L, Shaw MR, Strassburg BN, Tylianakis J, Verburg P, Visconti P, Zafra-Calvo N, et al. (2021) Conservation needs to integrate knowledge across scales. Nature Ecology & Evolution 6 (2): 118-119. https://doi.org/10.1038/s41559-021-01605-x
- Frazier A, Kedron P, Yang W, Quan H (2024) America the Beautiful: Meeting “30 × 30” Conservation Goals Through Connected Protected Areas. Annals of the American Association of Geographers1-17. https://doi.org/10.1080/24694452.2024.2410008
- Velásquez-Tibatá J, Olaya-Rodríguez M, López-Lozano D, Gutiérrez C, González I, Londoño-Murcia M, et al. (2019) BioModelos: A collaborative online system to map species distributions. PLOS ONE 14 (3). https://doi.org/10.1371/journal.pone.0214522

Supplementary material

Suppl. material 1: Scaling Spatial Planning Models to Support Conservation and Land Use Decisions under Climate Change doi

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